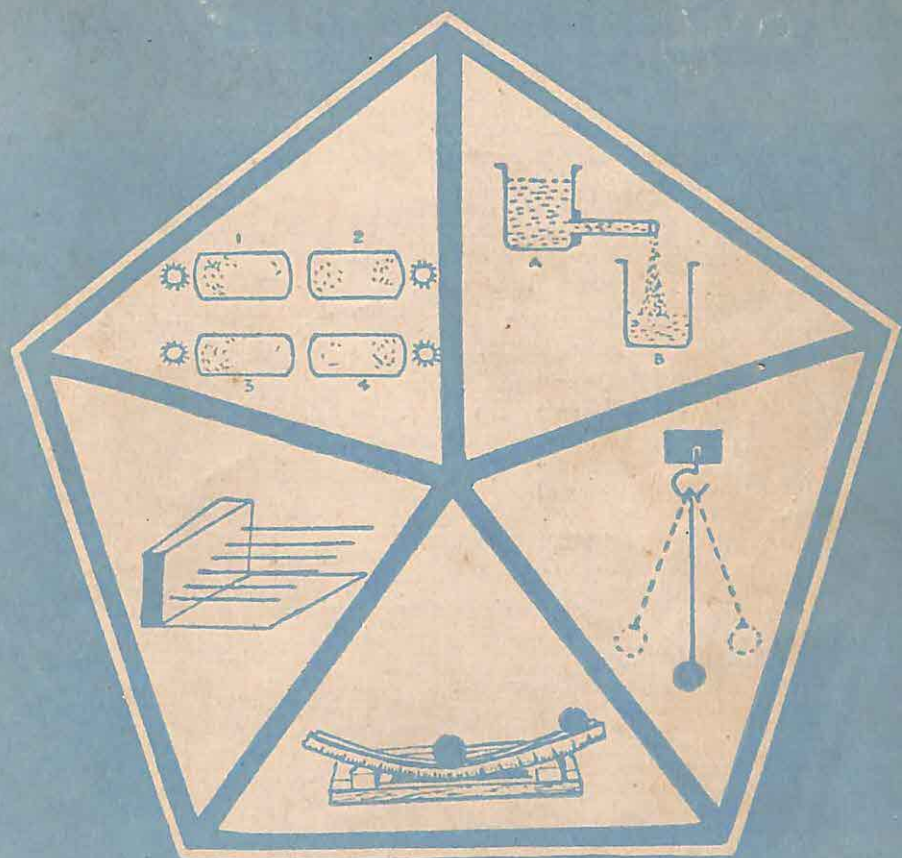


REGIONAL COLLEGE OF EDUCATION
AJMER



THE PIAGETIAN
JOURNEY

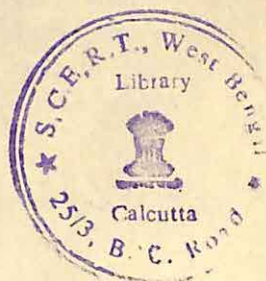
(1896 - 1980)

The Piagetian Journey

NARENDRA VAIDYA

Professor of Education

1982



Extension Services Department
Regional College of Education, Ajmer.

EXTENSION SERVICES DEPARTMENT
REGIONAL COLLEGE OF EDUCATION, AJMER



Prof. S. N. Dutta
Hon. Director and Principal

S.C.E.R.T., West Bengal

Date .. 14/12/84..

Acc. No... 3073...

Dr. G. N. Bhardwaj
Coordinator

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Phone : 23088

The Piagetian Conception of Knowledge

1. Knowledge is constructed. It is not a copy of reality nor an interpretation of reality. It is constructed both from the data of experience and from data provided by the biological characteristics of organism.
2. Knowledge is constructed in the mind of the individual by means of a self-regulating mental mechanism. This mechanism controls the functions of two processes. Assimilation involves the incorporation of the regularities (or general rules) of active experience into already existing mental structures. Experience is not sufficient for creating knowledge of the real world if the relevant structures are not available to incorporate the rules of that experience. The other process, accommodation, is one of applying or integrating already available structures of operations to new experience. Knowledge in this case is constructed out of the products of prior constructions.
3. The origin of thought is not to be found in the data of sensation or perception but in action, that is, in mental activity involving functions associated with prelogical and logical operations. Operativity, which may involve the use of sensory and perceptual data, leads to the construction of knowledge, while perceptual and sensory data per se do not.
4. The constructive nature of knowledge implies that the child or adult plays an active rather than passive role in creating knowledge. He is neither passive in his reasoning nor is he a passive recipient of stimulation from the physical world. The data of experience received through sensation and perception are not merely "representation" of

reality. Rather, they are incorporated into and integrated with existing structures in the mind through the action of intellectual operations. These symbolic representations whether sensory (kinesthetic, visual, auditory, etc.) or conceptual, are the products of, rather than the sources of thought.

5. Development of the capacity to construct knowledge is a long process. It proceeds by stages in the development of the individual. Although experience with the real world is necessary for constructing knowledge, mental mechanisms and processes which become functional only with the maturation of the organism are equally necessary. This suggests that the mechanism by which thought processes develop is under the control of species-specific genetic programming, and while experience may have the effect of accelerating or delaying mental development, it will not alter its essential character.

Harry Beilin

For many philosophers and epistemologists, epistemology is the study of knowledge as it exists at the present moment; it is the analysis of knowledge for its own sake and within its own framework without regard for its development. For those persons, tracing the development of ideas or the development of operations may be of interest to historians or to psychologists, but is of no direct concern to epistemologists.....But it seems to me that we can make the following reply to this objection. Scientific knowledge is in perpetual evolution; it finds itself changed from one day to the next. As a result, we cannot say that on the one hand there is the history of knowledge and on the other its current state today, as if its current state were somehow definitive or even stable. The current state of knowledge is a moment in history, changing just as rapidly as knowledge in the past has changed, and, in many instances, more rapidly. Scientific thought, then, is not momentary; it is not a static instance; it is a process. More specifically, it is a process of continual construction and reorganization.

Jean Piaget.

Unlike countries, science has 'open frontiers'. In this century, it has come of age: endless and faceless, stable and fluid, its inside exploding and imploding at the same time. At home, it lacks hypotheses setting and testing philosophy for it is still approached dogmatically in its entirety: teaching, telling, learning, experimenting and examining. How Children Discover Knowledge, therefore, attempts to illuminate the very reflective bases of Science by encouraging youngsters to innovate, master stimuli rather than restraints, while trying hard to reach destination with or without direction-for major scientific advances take place only when either the fairly well established body of scientific knowledge is challenged imaginatively or the most funniest scientific ideas are entertained, woven or left over partially by joining part fragments to each other like fibres in a long rope. The whole field of knowledge becomes active and exciting when Piaget seeks for similarities among epistemology, biology and psychology, which illumine the relationship between subject and the object.

N. Vaidya.

FOREWORD

The Extension Services Department in collaboration with the Department of Education of the college had for some time past been publishing research reports/research papers produced by the members of the staff of this college.

With the publication of the "Growth of Logical Thinking" by Professor Jean Piaget and Professor Barbel Inhelder, (1958) in Europe, worldwide interest arose on the investigation of adolescent thought. Since then, several researches by several workers have been appearing in different parts of the world.

Professor N. Vaidya has been working in this area for the last twenty years or so. Sometime back, we published one of his papers on 'The Piagetian Journey' which was very well received in the country.

Piaget raised thought provoking questions about the origin of knowledge and the Intellectual development of children over the last sixty years or so. Piaget saw the same event from several contexts simultaneously i. e. epistemology and science; philosophy and psychology; norm and fact; and reason and empirical investigations which had not been seen by the earlier philosophers like, Locke, Hume, and Kant. Throughout his life, he was misunderstood both by the philosophers and the psychologists. Despite his limitations, he flourished on misunderstandings because there is hardly any cognitive study considered worthwhile which does not take into consideration parts of his work.

There was a great demand for this publication, which went out of print so soon. Prof. Vaidya has slightly revised the publication and the same is with you.

We are thankful to Prof. Vaidya for his efforts. We also acknowledge our thanks to Miss Padmini, M. S., Project Fellow, who has prepared the bibliography for this publication.

Lastly, We hope that this publication would be of interest to teachers as well as researchers.

S. N. DUTTA
PRINCIPAL

August 9, 1982.

Regional College of Education,
Ajmer.

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*The Piagetian
Journey*



(1896-1980)

Introductory

Biographical Note

It is said that a really great man is one who halts progress, at least in his subject for about four centuries. In his life time, Piaget nearly won this distinction because he was no stranger in academic circles all over the world. Whereas his works were both acclaimed and ridiculed by the academicians, he built up his own Piagetian history, caring little either way, single handed, which, later on, became world famous as the Geneva School. About the slow and grudging acceptance of his work, which hardly clicked contextually among workers when it came to intense criticism, he has frequently said :

I am a naturalist and biologist by training interested in epistemological problems without ever having undertaken formal study (nor passed any examination) in psychology, my most central concern has always been to determine the contributions of the person's activities and the limiting aspects of the object in the process of acquiring knowledge. Fundamentally, it was the wish to resolve this problem using the experimental approach that brought me into the field of developmental psychology. But it follows logically since this point of view is not often held by psychologists in general and even less by child psychologists that those who read my work find themselves confused.

Piaget was born on August 9, 1896 in Neuchatel, a French speaking university town in Switzerland. Right from his early days he was very studious. He had also a lonely childhood because of the emotional outbursts of his neurotic mother and the detached attitude of his historian father. Interestingly enough, he wrote his first scientific paper at the age of ten for which he was offered the post of a curator at the local Natural History Museum, which however was withdrawn immediately in view of his low age. He obtained his doctoral degree in Zoology at the age of 22 on 'Mollusks of Valais'. By observing, dissecting and experimenting with them, he applied the knowledge so gained to the origin of knowledge as it grew historically and the way it developed inside the head of child scientifically. In this encounter, he did not know what he was to accomplish in his life. So he flirted with several ideas and read deeply and reflectively in philosophy, psychology, sociology and history of science etc. As his intellectual thirst did not quench, he went to Paris for pursuing clinical research at the Alfred Binet Laboratory. While he was paid for standardizing Burt's tests of reasoning, he deeply engrossed himself with pupil questions and errors which in a way provided him with missed insights into intellectual development.

Another scientific paper by him in this area won him in 1921 the job of Director of Studies at the J. J. Rousseau Institute in Geneva, a position which offered him ample opportunities for research and reflection. From this moment onward, he never looked back and was actively associated in different capacities with the following few universities like Neuchatel, Lausanne, Sorbonne, University of Geneva, as well as with the International Bureau of

Education and Centre for Genetic Epistemology. He taught and researched in philosophy, psychology, sociology and scientific thought. He also co-edited two journals, namely, *Archives de Psychologie* and *Revue Suisse de Psychologie* for several years. He spent a lot of time daily on writing articles, papers, monographs & books. Although very busy, he was still approachable and tolerated fools with courtesy and pleasure. At other times, he could be equally cold. He earned respect and regard abundantly from those who worked closely with him. In 1964, V. N. Rockcastle observed him quite closely when Jean Piaget guided a workshop on Cognitive Development under the auspices of the National Science Foundation of U. S. A. He found him little sophisticated, despite his keen international status. He loved simplicity, possessed a sense of humour and showed a twinkle in his big eye even when in disagreement. He knew the art of travelling light, that is, putting a small bag into a large one secretly for carrying back home his very dear and lovely mollusks and no 'Foren' goods. In 1971, he became Professor Emeritus of the University of Geneva. He retired from teaching in 1975 but, not at all, from research. He continued to write until the end of his life.

His Chronology of Publications

Undoubtedly, Piaget wrote profusely in his life time in French. How he wrote is a matter of conjectures to the outsiders. Consider his following publications translated in English, written singly and, in collaboration with others, starting from 1923 on wards.

- | | |
|---|------|
| 1. The Language of Thought of the Child | 1923 |
| 2. Judgement and Reasoning in the Child | 1924 |
| 3. The Child's Conception of the Physical World | 1926 |

4. The Moral Judgement of the Child	1932
5. The Origin of Intelligence in Children	1936
6. The Construction of Reality in the Child	1937
7. The Child's Conception of Numbers	1941
8. The Child's Construction of Physical Quantities	1942
9. Play, Dreams and Imitations in Childhood	1945
10. The Child's Conception of Time	1946
11. The Child's Conception of Movement and Speed	1946
12. The Child's Conception of Space	1948
13. The Psychology of Intelligence	1950
14. Play, Dreams and Imitation in Childhood	1951
15. The Origin of Intelligence in Children	1952
16. Logic and Psychology	1953
17. The Construction of Reality in the child	1954
18. The Strategy of Genes	1957
19. The Growth of Logical Thinking from Childhood to Adolescence	1958
20. The Child's Conception of Geometry	1960
21. The Early Growth of Logic in the Child	1964
22. Mental Imagery in the Child	1966
23. The Mechanisms of Perception	1969
24. The Psychology of the Child	1969
25. Science of Education and the Psychology of the Child	1969
26. Genetic Epistemology	1970
27. Biology and Knowledge	1971
28. Insights and Illusions of Philosophy	1971
29. Psychology and Epistemology Structuralism	1971
30. Understanding and Causality	1974
31. The Origin of the Idea of Chance in Children	1975
32. The Grasp of Consciousness	1976

33. To Under stand is to Invent	1976
34. Success and Understanding	1978
35. Behaviour and Evolution	1979

Surprisingly enough, this list is not complete for, he has authored a few more books whose titles could not be ascertained. This list also excludes several of his works written in French over the last several years. Several of his works in the area of perception are yet to be translated in English.

The Cycle of Intellectual Development

From the above mentioned chronology of his publication, it is abundantly clear that it is even difficult to read Piaget at one go. Perforce of circumstance, one has to start at one of the corners, go ahead on his Voyage of Discovery and see first hand the vastness of his difficult work. Having flirted elsewhere and, later on, delved deep in the Piagetian territory, the Indian author of *Some Aspects of Piaget's Work and Science Teaching* remarked in a poetic fancy : "I have loved Piaget more than I have loved my wife for his creative work and intriguing system which are as exciting as space travel and research." He is not one Piaget but several if one takes into account the multisided aspects of his work. He is not only very much aware of the theoretical implications of the work and attacking problems from one's weakest points in eyes of others, but also, he is quite imaginative and capable of choosing complicated techniques and methods relative to his select intellectual problems defined in the widest possible framework surpassing psychometry clearly and even development. Over a period of sixty years or so, he and his co-workers have contributed immensely to the whole field of psychology : perception, reasoning, intelligence, dreams, moral

development, space, time, play, thinking from early childhood to late adolescence and other highly varied problem areas, for example, physics, mathematics, biology and logic. From his highly theoretical, abstract and imaginative frame of reference, he has devised highly original physical experiments which have won him world-wide acclaim (e. g. conservation experiments) and are admired highly by the researchers on cognitive development. Result ? His theoretical frame of reference, an incomprehensible entity to many, possibly of less calibre, became a casualty, rather than a causality. Here, even Professor Flavell, is no exception, the first best American publicity officer Piaget had in the 60's.

The Distinguishing Characteristics of Stages in Brief

S. No.	Stages	Age Range	Brief Characteristics and Abilities
1	2	3	4
1	Sensory Motor Period	0-2 years	1. Child is born with reflexes and reflex-like behaviours, thus, making interaction with the environment possible. 2. Such developing behaviours are modified by experience, which are, logically speaking, explicable increasingly. 3. Curiosity appears when there is a discrepancy between the new experience and the past experience. 4. Appears to throw whole of himself physically in the activity. Performs only overt activities. 5. He is attracted by sound, touch and other physical stimuli, while crawling, he is on a voyage of discovery. He thinks least of his actions.

1	2	3	4
			6. Actions become gradually intentional. Object concept develops. 7. Is highly dependent upon his parents for satisfaction of his physical needs. 8. Flat pictures do not attract his attention but if he is given a pencil, he can stretch his hands to grasp it. 9. Develops language prominently towards the closing end of this stage which was really not there.
2	Pre-operational or Pre-logical Stage	2-7 years	1. Sees things in his own frame of reference. 2. Can think of only one idea at a time. 3. Shows the following three modes of reasoning, viz, simple memory for past experience, desire for distort thinking and reasoning from particular to particular at the cost of underlying unity.

1	2	3	4
			4. Attempts to use abbreviated visual image, symbols and motor sequences for activities and events. 5. Carries on conversation with himself and in this, he least cares for mutual communication. 6. Uses language in a limited way. Why ? Because he feels difficulty in expressing his thoughts. 7. Although performance is highly rigid and narrow, use of logical tasks definitely facilitate thinking. 8. His social interests begin to widen and he tends to become less and less self centered. 9. Cognitive growth takes place when attempts are made to reconcile cognitive conflicts.
3	Concrete Operational Stage	7-11 years	1. Thinking is tied to the concrete situations. Takes care of complex classifications and conservation of number length, quantity, weight and area.

1	2	3	4
3			2. Does not accept hypothetical data, that is, cannot react to abstract situations. 3. Reality dominates possibility and possibility is subordinated to it. 4. Controlled experimentation is conspicuous by its absence. 5. Jokes pitched at the concrete level only are appreciated. 6. Thinking takes gradually a more socio centric character.
4	Formal Operational Period	11-15 years	1. The barriers, if any, on thinking are removed. In other words, the thinking is no longer tied to the concrete situation. 2. Possibilities as well as idealism dominate thinking. Now are imagined and considered all sorts of facts, concepts, hypotheses and tentative stabs.

1	2	3	4
			3. Ability to set up as well as test hypotheses appears markedly. The essence underlying controlled experimentation is grasped. Thus, the individual minds of adolescent pupils begin to become experimental. 4. Contradictions as well as paradoxes begin to receive attention for resolution in a wider context. Deductive experimentation becomes possible. 5. Reflection on reflection appears for added clarity. Even assumptions are not spared. Thought continues to move ahead. With the passage of time, equilibria at higher levels are sought. 6. Form rather than the content of the the problem is found to be increasingly grasped.

Taking an over all view, action becomes the basis of knowledge where by, with the acquisition of knowledge, the external reality is incorporated inside. There is the transition of thought from stage to stage. Jean Piaget visualizes the following five conditions when thought moves from the third stage to the fourth stage.

1. The adolescent pupil is in a position to state as well as test hypotheses. This type of reasoning is called the hypothetico-deductive one.
2. The adolescent pupil is able to make the effective use of proportional logic.
3. The adolescent pupil is in a position to separate form from content. Where possibility rather than reality becomes the chief distinguishing characteristic of his thought.
4. The adolescent pupil is able to deal effectively with the entire combinatorial nature of operations that is, from the 16 binary combinations to 256 tertiary operations.
5. The adolescent pupil is in a position to generate all the possible cases which are derivable from 'one single identifiable mental structure i. e. the INRC group'. It is a fascinating mental structure arising from the 'fusion of two different structures,' namely, the lattice and the group of reversibilities.

According to him, intelligence developes in four stages. These are : Sensory Motor (0-2 years), Pre-logical (2-7 years), Concrete (7-11 years) and Formal (11-15 years). Recently, he has hinted at the possibility of the fifth stage which covers the period from 15 to 20 years after taking into account factors like aptitude variations and commitment

to individual careers against the backdrop of now less prominent general intellectual development. The first stage is of little educational significance but, at the same time, is at the bottom of all the succeeding stages. In the second stage, the thinking or reasoning is transductive, that is, from particular to particular. At the third stage, reality dominates thinking which is reversed at the fourth stage. Here, the adolescent pupil can set up all sorts of hypotheses, test in varied contexts through control experiments, and may eventually pick up the various elements of scientific methods. Piaget then links up these stages with his self designed symbolic logic, a branch of mathematics, for analysing intellectual behaviour. Further, computer science is brought in and the whole scientifically discovered processes of pupil thought are very carefully hooked to the origin of knowledge, and, hence, experimental epistemology. It is then not difficult to see the passage of thought from stage to stage and the attainment of the highest rationality, potentially speaking in man.

Other Related Works

Incomplete conjectural research work very frequently raises more questions than it answers. His work met the same destiny as is seen by the diverse publications in different areas of work which appeared in the sixties and seventies. Where as the work of Piaget is supported in principle by the various authors, no systematic statement about the testable hypotheses so far appears for judging the weakness of the system. Even the main research frontier of logical thought now extended upto 20 years of age awaits immediate invasion. Now consider the chronology of publications by others which runs parallel to his main work.

- | | | |
|---------------|--|------|
| 1. Oaks N, E. | Children's Explanation of
Natural Phenomena | 1947 |
|---------------|--|------|

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|--------------------------------------|--|------|
| 2. Isaac S. | Intellectual Growth in Young Children | 1948 |
| 3. (i) Inhelder Barbel | Experimental Reasonings of Adolescents | 1955 |
| (ii) Inhelder Barbel | Learning and the Development of Cognition | 1974 |
| (iii) Inhelder Barbel et al (Edited) | Piaget and His School | 1976 |
| 4. Keats J. A. | Formal Concrete Thought Processes | 1955 |
| 5. (i) Lunzer E. A. | Recent Studies in Britain Based on the Work of Jean Piaget | 1960 |
| (ii) Lunzer E. A. | On Children's Thinking | 1970 |
| 6. (i) Peel E. A. | The Pupils' Thinking | 1960 |
| (ii) Peel E. A. | The Nature of Adolescent Judgement | 1971 |
| 7. Lovell K. | The Growth of Basic Mathematical and Scientific Concepts | 1961 |
| 8. (i) Flavell J. | The Developmental Psychology of Jean Piaget | 1963 |
| (ii) Flavell J. | Cognitive Development | 1977 |
| 9. Ripple R. E. & Rock U. N. | Piaget Rediscovered | 1964 |
| 10. (i) Wallace J. C. | Concept Growth and the Education of the Child | 1965 |
| (ii) Wallace J. C. | Stages and Transitions in Concept Development | 1972 |
| 11. Almy N. | Young Children's Thinking | 1968 |
| 12. SCIS | Curriculum Study Source Book | 1968 |
| 13. Siegel I. E. | Logical Thinking in Children | 1968 |

- | | | |
|---------------------------------|---|------|
| 14. (i) Vaidya N. | Problem solving in Science | 1968 |
| (ii) Vaidya N. | Some Aspects of Piaget's Works & Science Teaching | 1971 |
| (iii) Vaidya N. & Rajput J. S. | Reshaping our School Science Education | 1976 |
| (iv) Vaidya N. | The Growth of Logical Thinking in Science During Adolescence | 1979 |
| (v) Vaidya N. | Concept Formation | 1980 |
| (vi) Vaidya N. | The Emerging Psychological Frame of Reference in Our School Science | 1980 |
| (vii) Vaidya N. & Padmini M. S. | The Mathematical Structures Underlying Adolescent Thought | 1980 |
| (viii) Vaidya, N. | Researches on Adolescent Thought : A Framework | 1982 |
| 15. Furth H. G. | Piaget and Knowledge | 1968 |
| 16. Ginsburg H. et al | Piaget's Theory of Intellectual Development | 1968 |
| 17. Beard R. M. | An Outline of Piaget's Developmental Psychology | 1969 |
| 18. Boyle D. G. | A Student's Guide to Piaget | 1969 |
| 19. Elkind David & Siegel | Studies in Cognitive Development | 1969 |
| 20. Karplus R. et al. | The Developmental Theory of Piaget | 1969 |
| 21. Richmond P. U. | An Introduction of Piaget | 1970 |
| 22. Green et al. | Measurement and Piaget | 1971 |
| 23. Mischel T. | Cognitive Development and Epistemology | 1971 |
| 24. Pulsaki M. S. | Understanding Piaget | 1971 |

25. Bolton Neil The Psychology of Thinking 1972
26. Science 5/13 PROJECT 1972-75
27. UNESCO The Development of Scientific and Mathematical Concepts 1972
28. Díenes Z. P. The Six Stages in the Process of Learning 1973
29. Mc Nally D. W. Piaget, Education and Teaching 1973
30. [i] Collis K. F. Cognitive Development & Mathematics Learning 1974
- [ii] Collis K. F. The Development of Formal Reasoning : A Research Report 1975
- [iii] Collis K. F. A Study of Concrete and Formal Operations of School Mathematics 1975
- [iv] Collis K. F. et al Classroom Example of Cognitive Development Phenomena 1979
31. [i] Modgil S. et al The Piagetian Research 1974
- [ii] Modgil Sohan & Celia Piagetian Research (Eight volumes) 1976
- [iii] Modgil S. et al Toward a Theory of Psychological Development within the Piagetian Context 1979
32. Phillips D. G. Research Related to the Work of Jean Piaget 1974
33. Schwebel Milton et al [Edited] Piaget in the Classroom 1974
34. Hoope et al Multi-dimensional Scaling of Piagetian Task Performance 1975

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|--------------------------------|--|------|
| 35. Howard E. Grubber
et al | The Essential Piaget | 1977 |
| 36. Gebber B.A. [Edited] | Piagetian Psychology | 1977 |
| 37. Floyd Ann | Cognitive Development in
School Years | 1979 |
| 38. Lawson Anton E. | The Psychology of Teaching
for Thinking and Creativity. | 1979 |
| 39. Wadsworth, Barry | Piaget's Theory of Cognitive
Development [Second Edition] | 1979 |
| 40. Modgil, Sohan and
Celia | Toward a Theory of Psycho-
logical Development | 1980 |
| 41. Sandeep, Ponab. | Schools and Mental Abilities | 1981 |

Piaget was a great polymath who did not at all hesitate asking big questions considered definitely out of bounds by the contemporary twentieth century psychology and provided experimental answers to the philosophical questions, contrary to the philosophical tradition of Socrates, Plato, J. S. Mill, John Locke, David Hume and Immanuel Kant, to mention only a few. The spate of the above mentioned books within the last two decades shows that the Piagetian territory is nascently fermenting, actively healthy and kicking, and definitely productive, either way, (because failure in science is not a rare event !) and hence, can't be wished away for he showed relationships between his experimental epistemology and the entire human sciences.

A Factor Analytic View of Adolescent Thought

Jean Piaget stuck to one variable. namely, 'knowing' which reflected, later on, the most recent definition of psychology as the 'Science of knowing'. He did not consider any other variable even for covariation purposes. On the other hand, he suggested certain schemes of thought along with their corresponding experiments where schemes loosely mean : 'strategy, concept, plan, decision, process, orientation, sequ-

ence of links, learning set and key factor having past, present and future'. If the current status of research at the formal level in this field is evaluated, one really draws a blank. So there was hardly an opportunity available for the application of a highly mathematical or statistical technique called factor analysis on narrowly conceived studies for its chief objective is to 'simplify a large number of variates in experimental data to a smaller number of hypothetical variates that represent weighted sums of the observed variates'. To illustrate, when large number of variables are causally intertwined in a complex way and subjected to factor analysis, minimum number of factors appear which if hypothesized intelligently are easily interpretable with the help of marked variables. It is of interest to mention here that N. Vaidya, T. S. Sandhu and M. S. Padmini used 45, 39 and 31 variables respectively in their studies. Where as Vaidya pitted similarly hypothesized internal structures across the various problems incorporating several schemes of thought, Padmini pitted only one scheme of thought against several variables in their varied contexts. In all the three developed test instruments, most of the individual tasks had their co-efficients of reliability and validity within acceptable limits. Few tasks were simply retained because they attracted significant aspects of adolescent thought. These three studies, still of exploratory nature, along with the studies of other workers attempted abroad do provide a worth while ground where the psychometric and developmental approaches employed in investigating intelligence could merge, a case which was hardly there even before a decade ago despite the fact that past studies on intelligence within the span of 75 years or so had evoked sharp divergence of opinion. In this context alone, the following factorial picture of intelligence appears from the developmental point of view.

The Current Picture of the Factorial Structure of Adolescent Thought of

S.No.	Factor	Psychological Interpretations	Author (s)
1	2	3	4
1.	First Factor	(i) General Intellectual Factor (ii) Schematic Learning General (iii) Attainment Factor (iv) Algebraic Aptitude (v) General Adjustment (vi) Formal Operational Thought	Abou Hatab (1964), Beard (1957) Delemos(1969), MacArthur(1968), Peel (1955), Sandhu (1980). Staver and Gabel (1979), Tuddenham (1970), Vernon (1971) Vaidya and Sandhu (1981) Bart (1971), Renner and Lawson (1975), Vaidya (1975), Jain (1982). Vaidya (1964) Joshi (1970) Vaidya and Misra (1975) Abramowitz (1975)

1	2	3	4
		(vii) Exclusion of Variables (viii) Language Factor	Shayer (1978) Padmini (1982)
2	Second Factor	(i) Practical Factor (i i) Symbolic Substitution (iii) Adjustment (iv) Seeing the Problem as a Whole. (v) Piagetian Cognitive Development (vi) Academic Achievement Factor (vii) Creativity (viii) Exclusion of Variables (Testing of Hypotheses)	Vaidya (1964) Joshi (1970) Vaidya (1975) Vaidya and Misra (1975) Staver and Gabel (1979) Sandhu (1980), Vaidya and Sandhu (1982) Jain (1982) Padmini (1982)
3	Third Factor	(i) Interest Factor	Vaidya (1864)

1	2	3	4
		(ii) Problem Orientation (iii) Formulating Hypotheses (iv) Piagetian Logical Operations Test (v) Adjustment Factor (vi) Stating and Testing of Hypotheses. (vii) Achievement (viii) Exclusion of Variables (Stating of Hypotheses)	Vaidya (1975) Vaidya and Misra (1975) Staver and Gabel (1979) Sandhu (1980) Vaidya and Sandhu (1981) Jain (1982) Padmini (1982)
4	Fourth Factor	[i] Adjustment Factor [ii] Sensing Problems [iii] Tackling Algebraic Symbols [iv] Interest in Generating Difficult Problems [v] Behavioural Factor [vi] Super Ego Strength	Vaidya (1964) Vaidya (1975) Vaidya (1975) Vaidya and Misra (1975) Sandhu (1980) Vaidya and Sandhu (1981) Padmini (1982)

1	2	3	4
5	Fifth Factor	[i] Problem Orientation [ii] Symbolization [iii] Newness of the Problem [iv] Emotional Factor [v] Premsia [vi] Group Factor of Personality [Dominance, Guilt Proneness, Ergic tension]	Vaidya [1975] Vaidya [1975] Vaidya and Misra [1975] Sandhu [1980] Vaidya and Sandhu [1981] Padmini [1982]
6	Sixth Factor	[i] Testing Hypotheses [ii] Using Constant Difference [iii] Temperamental Factor [iv] Self Sufficiency [v] Permutations and Combinations	Vaidya [1975] Vaidya [1975] Sandhu [1981] Vaidya and Sandhu [1981] Padmini [1982]

1	2	3	4
7	Seventh Factor	[i] Aspect Character [ii] Using Constant Difference [iii] Group Factor of Adolescent Thought—I (iv) Parmia (v) Mechanical Reasoning	Vaidya [1975] Vaidya [1975] Sandhu [1980] Vaidya and Sandhu [1981] Padmini [1982]
8	Eighth Factor	(i) Exclusion of Variables (ii) Aspect Character (iii) Social Factor (iv) Adjustment (v) Self-Sufficiency	Vaidya [1975] Vaidya [1975] Sandhu [1980] Vaidya and Sandhu (1981) Padmini (1982)
9	Ninth Factor	(i) Combinatorial Grouping (ii) Seeing Problem as a whole (iii) Group Factor of Personality—I	Vaidya (1975) Sandhu (1980) Vaidya and Sandhu (1981)

1	2	3	4
		(iv) Space Relations (v) Age	vaidya and Sandhu (1981) Padmini (1982)
10	Tenth Factor	(i) Intelligence (ii) Verbal Description Procedures. (iii) Abstract Thinking Factor (iv) Surgency (v) Parmia	Vaidya (1975) Vaidya [1975] Sandhu [1980] Vaidya and Sandhu [1981] Padmini [1982]
11	Eleventh Factor	(i) Group Factor of Adolesceot Thought—II (ii) Excitability (iii) Ego Strength	Sanhu [1980] Vaidya and Sandhu [1980] Padmini [1982]
12	Twelfth Factor	(i) Stating and Testing of Hypotheses (ii) Intelligence	Sandhu [1990] Padmini [1982]

1	2	3	4
13	Thirteenth Factor	Group Factor of Personality-II	Sandhu [1980]
14	Fourteenth Factor	Group Factor of Adolescent Thought-III	Sandhu (1980)

*Some factors from the bottom upwards could be eliminated through scree test.

It is now possible to provide a few closing remarks. Different workers, having different objectives in mind, have extracted diverse factors using different tasks and tests, populations and techniques of analysis. Secondly, the results of all these studies indicate that the formal stage which appears during adolescence is just being scratched factorially. Thirdly, there is yet to become available a single study investigating Piagetian thought in full without violating the underlying assumptions of the Genevan view point. If some pointers in this direction are any guide towards the clarity of the field, the developing picture, structurally speaking, is some what as follows :

- (i) Piagetian tasks as given in the 'Growth of Logical Thinking' as well as similar tasks inhering a continuous chain of reasoning, measure what is called 'formal thought' (Bart, Gabel, Gurein, Jain Lawson, Lovell, Lunzer, Misra, Peel, Renner, Sandhu, Shayer, Staver Padmini and Vaidya)
- (ii) Formal thought is necessary to proportional reasoning (Lovell and Lunzer.)
- (iii) The structure of formal thought is bi-factorial, viz, Verbal and Non Verbal (Bart).
- (iv) Analytic thinking, intuitive thinking and strategy appear during adolescence. (Abou Hatab, Austin, Goodnow and Guilford).
- (v) Adolescent thought shows a form of grouping : Concrete operational and coordinating concrete-logical (Gurein).
- (vi) The factorial structure sex-wise during adolescence is not the same on Piagetian type Tasks presented individually as well as in a group (Lawson and Vaidya).

Everlasting Nature of His Work

It is difficult to answer this question. Having been trained as a physicist, I did not know what I was doing while working on thinking : Concept development, problem solving and their underlying mathematical structures. Through sheer chance, I came across one of his books and found it too annoying. If one is really serious and works on the problem from its first fundamentals, one curiously enough, finds oneself playing on a sea-saw with Piaget. The intellectual swing is experienced and then, one gravitates towards or away from his territory. This is not the way of answering the above mentioned academic question. But here, it has to be so. Why ? Whereas his journey had earlier begun from Mollusks to Moppets, mine began from the failure of understanding the deficit learning situations through teaching methodology, deaf. to the mentality of children. To illustrate the difficulties :

Imagination, ingenuity and skill open up several diverging perspectives for any age old problem stated in its very fundamentals. From the study of Mollusks, he formulated problems productively for the theory of knowledge for the next six decades by observing them, 'ferreting out their notions of time, space, numbers and ethics as he sprawled on the ground shooting marbles and playing other games' in the words of John Leo. Thus he challenged the then current wisdom about child development. As the time went by, he became a legend in his time with eyes ablaze as he tackled a series of intellectual problems, one after another. Consequence ! The splitting of Piaget ! He is Piaget Number One when one considers his slipshod work on cognition. He is Piaget Number Two if one considers his truly scientific

work on perception. He is Piaget Number Three when one considers the educational implications arising out of his work. He is Piaget Number Four when he begins to revise his ideas very fast in the light of after thought, criticism, contradictory data and self critical reflection. He is Piaget Number Five when he lifts a particular problem from its lowest plane to its highest epistemological plane where by a sort of parallelism is established the way the idea was historically developed on the one hand and the way it arose scientifically in the child's mind right from its moment of inception. He is Piaget Number Six in the eyes of those who imagine that the basic Piagetian tenets cannot be proved wrong. He is, in the end, Piaget the Miscellaneous when he flourishes on misunderstandings raked up by those who do not understand him, or accuse him of not solving those problems which he did not propose to do. Whatever be the elephantine aspects of Piagetian work, any one who "came close to him affirms to his greatness after all because 'it was a famous victory' at its best or the so called flop at its worst. The answer to the question raised above can now be answered as best as possible as follows :

1. "Nature desires that children should remain children before they are men", echoed Rousseau. Piaget made this clear distinction scientifically, using Methode Clinique, saying thereby, that child is not a little adult.
2. He provided the psychological theory of operations which developes in stages. Operations are actions which are internalized and reversible. They can be thus distinguished from simple action or goal directed behaviour.
3. There is constant interaction between the organism and the environment out of which develop intellectual

structures sequentially. Thought accords with things, actions, and even with itself in the inseparable functioning of organization and adaptation

4. Equally proficient in zoology, logic and epistemology, he provided rich vocabulary having very deep meanings : adaptation, centration, conflict equilibration, isomorphism, INRC group, operation, reversibility and scheme of thought etc.
5. He brought out clearly the limitations of associationism structuralism, functionalism, behaviourism, and Gestaltism. He developed experimental epistemology. Also he did not favour acceleration of thought.
6. In the Growth of Logical Thinking From Early Childhood to Late Adolescence, he propounded an open research frontier which is yet to be verified as well as tested.
7. His theory does not generate sharp hypotheses which can be tested easily by psychometry. The factorial interpretation of his work is just coming up.

Contradictory Comments

It is said that the five blind persons of Hindustan could not reconstruct the whole elephant for their individual observations lacked synthesis. Similarly, understanding Piaget in toto is a difficult enterprise. By putting aside the two variables of feeling and doing, he concentrated on the variable of cognition which he regarded as fundamental. While working with children, partly speculatively and partly experimentally and that also unscientifically, he interpreted the developing House of knowledge of an Epistemic (Universal) child by giving it an epistemological base

which was objected to by the epistemologists. Consequently, he put up his own web by picking up threads from the various sciences in the name of so called synthesis called compound in contrast to mixture in the language of chemistry. It is this compound which is highly sensitive to the past knowledge and is also a competitive construct of the things likely to be. It is, therefore, least surprising that his work has evoked diverse criticism. So by his critics, he has been described as :

Discoverer or an unsuspected dimension of truth (Isaac Nathan); Mastering at developing the theoretical implications of his work (Hunt); Zoologist by training, an epistemologist by vocation and logician by method (B. Inhelder); in continuation psychologist by accident (D. M. Hade); educator by mistake (N. Vaidya); an indelible colourizer (J. Flavell); capable of hypothesizing or producing child following any system of logic (K. Lovell); a sort of bull's eye hitter (N. Vaidya) having 'scant regard for statistics, standardized tests and procedures' with speculation thrown in (Eric Lunzer) and Le Patron as lovingly called in Geneva (4).

Even Jan Smedslund could not help commenting after having been ardenalized by the Piagetian territory for about eight years :

I probably owe more to Piaget than to any other single psychologist, yet I have become increasingly critical of his theoretical system. Working with children during my Piagetian period, I felt constrained to be detached, one sidedly cognitive and entirely focused upon certain very abstract aspects

of performance. What mattered to me then were the formal logical structures rather than the concrete living children in their total life situations. I tended to ignore the artificiality of the tasks and I was oblivious of the political implications of my work as supporting a one-sidedly intellectualistic and school-centred ideology. I doubt that practitioner can be a useful psychologist if he remains within that tradition. Piaget has contributed a wealth of brilliant and penetrating insights but they must be incorporated into a view of psychology which can be lived or practiced rather than merely written and talked about in academic settings.

Borrowing from physics, it is simply a case of polarization after his interaction with Piaget because any logico-mathematical structure could be traced from its moment of origin under emotive conditions as well. It is precisely for this reason that Piaget ran away, literally speaking, from psychoanalysis. Even this remark may not hold true when he wrote another thought provoking book on the Grasp of Consciousness towards the fag end of his life where he made children perform interesting activities, for example, Walking on All Fours and the Flying Balloon with a view to understand how consciousness, preconscious and unconscious hang together when children, varying over a very wide age range, begin to reflect on their actions and continual reflection on each other leading to conceptualization, understanding and failure. His use of vocabulary has specialized meanings. For illustration, take the word : Cognizance which he used when any subject fully becomes conscious of a situation. To quote Piaget :

The study of Cognizance has led us to place in the general perspective of the circular relationship bet-

ween subject and object. The subject only learns to know himself when acting on the object, and the latter can become known only as a result of progress of the actions carried out on it. This explains the circle of the sciences, of which the solidarity that unites them is contrary to all linear hierarchy. Furthermore and most importantly, this explains the harmony between thought and reality. Since action springs from the laws of an organization, that is, simultaneously one physical object among many and the source of the acting, then thinking subject.

Here is provided the inside developing picture of the black box nearly ignored by the behaviourists within the S-R paradigm trying hard to push back Sigmund Freud, J. B. Watson, B. F. Skinner, Robert Gagne, Max Wertheimer, Karl Duncker, J. S. Bruner, and Ausubel. The same remark appears to apply to the advocates of heuristic method, inquiry training, guided discovery and creativity. So scheme, schema and schemata become the better bets when it comes to the development of educational constructs for the Education of the Head.

Educational Implications Based Upon the Genevan School

True to the best tradition of pure mathematics and science, Piaget uttered very little on the education significance of his vast work. Here, he need not be taken literally despite the fact that he used to say frequently, "I am not interested in psychology, education and children." It does not amount to going too far when he says that children learn through self activity. Secondly children learn from each other in group situations. Thirdly, teachers are completely mistaken if they think that they can give an idea to their pupils; and

that pupils have completely mastered the concept, if they give the right answer to the teachers' questions. They may accommodate to the new knowledge, a case of false knowledge in the phraseology of E. A. Lunzer, but it is only through their thinking and action of things, objects and ideas that they assimilate knowledge. They themselves have to be quite active in furthering their own knowledge. So he emphasizes Education for Understanding through exploration and invention of operation. Novelties of thought are created this way because teaching means creating structures which are pupil discovered rather than transmitted to pupils, available only for blurring out askance during examinations. He appears to be silent on incentives, rewards, and motivation. In his scheme, they are not raised to the status of mental structures necessary for spontaneous development. Only certain logico mathematical structures in diverse subject matter areas in science and mathematics, social awareness, of course, not excluded, are strictly speaking, given weight-age. In the Essential Piaget, Howard E. Gruber and J. Jacques Voneche schematize the following four possible educational approaches based upon the application of the Piagetian ideas :

1. Taos : respect for the individual artisan. Abundance of semi-structured instructional and illustrative materials drawn from diverse fields of knowledge.
2. Paris : pleasures of discussion between equal partners.
3. Athens : as reflected in the Socratic method.
4. Eldorado : as reflected in inquiry and discovery methods.

Let us now refer to the work of other Piagetian workers. First is the Karplus Cycle of Learning. Robert Karplus and his co-workers have developed three distinct

types of lessons in science which fascinate as well as fire the imagination of young children. In the first lesson, the child is asked to explore the given semi-structured materials in any way he likes. In the second lesson, he is compelled to invent the concept. In the third lesson, after the concept is fairly firmly introduced, he is expected to apply it, and thus, see its utility and futility in other situations. Thus, the teaching-learning situation is suitably adapted in an open manner to meet the mentality of children in the development of Piaget inspired Science Curriculum Improvement Study Project in U. S. A. Apart from the significant works of Professors Peel, Lovell, Lunzer and Beard in U. K., Dr. Wynne Herlen has also done creditable work in matching natural environment to children's educational development the Piagetian way not only in the area of concept development in science but also in a very wide frame of reference as exemplified in the progress in Learning Science Project for youngsters. Equally of great interest is the work of Dr. Michael Shayer which examines the conceptual demands made by a couple of scientific subjects on British G. C. E. children. Again in the Piagetian context, his work contributes to the science of science teaching in any situation seen to be a learning deficit one.

The centre now shifts to Australia. Fourthly, in the same Piagetian context, Professor K. F. Collis and Professor J. B. Biggs in their recent publication on Classroom Examples of Cognitive Thought : The Solo Taxonomy, have illustrated a rating scale where any given pupil response evoked by a specific task each drawn from several school subjects could be placed on any one of the following points or levels, namely, Pre-structural, Uni-structural, Multi-structural Relational & Extended abstract regardless

of the different levels of intellectual development : Pre-operational, Early concrete, Middle concrete, Concrete generalization & Formal as defined by the Geneva school. On the very face of it, this Australian Taxonomy very clearly impinges simultaneously in the triple areas of Curriculum, Teaching Methods and Evaluation. If carefully applied, this exercise very clearly brings out the main strengths and weaknesses of pupil responses emitted in raw in the individual contexts of the various problems used in day to day classroom teaching. And when these responses are seen and examined cross-sectionally, they in a way inform the practising teachers about the properties of pupil thought processes at succeeding age levels. Whereas the Piagetian way focusses the consequent educational issues convergently, the Australian SOLO diverges, possibly the same, for the benefit of the Australian teachers to meet individual differences when pupils at different levels of development are found in the same class. And this is going to be a global classroom phenomenon.

Now coming home, not long ago, Professor J.K. Shukla talked of Need for Self Directed Change in Colleges of Education in India. Inspired by this ideal, Professor Vaidya and Dr. B. K. Sharma developed a Science Teacher Behaviour Inventory after having injected in it the Piagetian flavour. It had the following six dimensions, namely, Structuring the teaching, Structuring the learning, Structuring the materials, Structuring the classroom control, Silent activity and Confusion. Professor Vaidya and Dr. T. S. Sandhu have documented studies hinting at the distinct Possibility of Hump Effect during the transitory stage between the concrete and formal stages of mental development in the problem solving context. Prof. Vaidya and Shri S. C. Jain are presently

engaged in studying advanced problem solving processes in physics. Equally worth referring to is an ERIC (NCERT) project in progress on the Determination and Development of Schemes of Thought in Science During Adolescence at the Regional College of Education, Ajmer. A chip of this project relates to the Acceleration of Thought on the Construct of Exclusion of Variables During Adolescence which is being studied by Professor Vaidya and Miss Padmini. Both of them have documented and made available a vague factorial structure of adolescent thought in the Piagetian context. Combining creativity, least understood in the Piagetian context, with the above mentioned hypothesized construct is being investigated by Mrs. Avinash Grewal at Regional College of Education, Bhopal. The Educational implications arising out of these works may not be round the corner but they will definitely go a long way in clarifying several intellectual issues in the area of methodology of teaching, particularly speaking, concept formation and problem solving as well as its modern versions like inquiry or discovery approach.

Lastly, Piaget's ancestry can be traced back to the intelligence testing at the Binet laboratory in Paris. Unlike others, he negotiated imaginatively round the Corner of Errors in assessing the nature of intelligence the other way round. With this step, he has influenced the initial, middle and end games of several workers all over the world. Like him, they are also now engaged in delineating this Piagetian territory very lovingly. Obeying the famous Inverse Square Law in Physics, nobody, beyond 10 kms. or so away from Geneva knows the full import of Piaget's work where both its substance and shadow intermingle imperceptibly. The negotiating here is becoming nearly impossible especially when Piaget is too fast in revising his ideas in the light of further reflection and criticism. All of us, therefore,

interpret. His Trace in the heat of the moment. The Vision of his work, may it be a case of one sided interpretation, puts aside on the road several of the thinkers usually encountered in educational literature when it comes to the Education of the Head. In this context, what ought to be the main aim of education, again to quote Piaget :

The principal goal of education is to create men who are capable of doing new things, not simply repeating what other generations have done....men who are creators, inventors and discoverers. The second goal of education is to form minds which can be critical, can verify, and do not accept everything they are offered. The great danger today is from slogans, readymade trends of thought. We have to be able to resist individually, to criticize, to distinguish between what is proven and what is not. So we need pupils who are active, who learn early to find out by themselves, partly by their own spontaneous activity and partly through material we set up for them, who learn early to tell what is verifiable and what is simply the first idea to come to them.

Scientists discovered penicillin in the mouldy bread. About 800 years ago, Plato talked of cutting off the problems at their joints. In the process of interiorization of knowledge founded on action, Jean Piaget appears to have cut off several joints in the area of cognition by giving each of them an epistemological context within the black box as visualized by the behaviourists between Stimulus and the Response for the benefit of carrying out the needed structural improvements in the teaching-learning process by the practising teachers who may now know how to act decisively when they know how the human mind reacts to concrete and abstract situations at the various levels of intellectual development implying thereby

that more and more inputs in education may not lead to more and more astounding results for vice versa may even hold true in the Genevan context. So, in the name of modernization, if any country simply down grades the content, it is bound to generate allergies all around within its borders for the basic Piagetian essence process at the cost of Product is just missing in this scheme. In summary, spin off advantages, await round the corner if one cares to turn one's gaze on the Genevan School so laboriously built imaginatively under the leadership of Professor Jean Piaget, the polymath when he said :

The fundamental hypothesis of genetic epistemology is that there is a parallelism between the progress made in the logical and rational organization of knowledge and the corresponding formative logical processes. Of course, the most fruitful field of study would be reconstituting human history—the history of human thinking in prehistoric man. Since this field of biogenesis is not available to us, we shall do as biologists do and turn ontogenesis.

From this, according to A. Blanchet and others, emerges the finest educational principle meeting diverse individual differences of the growing youngsters : It Must Permit the Child to Establish Plans to Reach Distant Goals, While Leaving him Wide Open Freedom to Follow His Own Routine. The gap between the learning in the classroom and outside of it is closed for parts of the hidden environment open up as naturally as Learning to Walk through the three lines of Access to Knowledge, namely, Perceptual, Acting and Conceptual. The world need no longer pass by as usual for it is the business of the human mind to go on creating novelties, each more novel than the other, for we do participate in the intellectual race trailed by Einstein, Freud, Chomsky and Piaget, to mention a few in this century.

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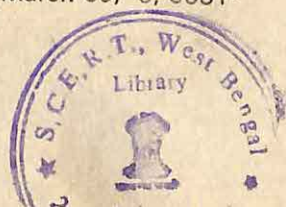
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